USING GIS TOOLS TO ANALYSE EMERGENCY AND CIVIL PROTECTION SITUATIONS SPECIFIC ISSUES

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Abstract: Geographic information systems are applicable in a wide range of areas as they allow data to be managed, analysed and distributed. The main purpose of this article is using GIS tools to explore the possibilities of analysing specific aspects of emergency and civil protection situations, amid a national security crisis. For such analysis, the ArcGIS Pro software proved to be very useful and the ability to operate with open data from Living Atlas facilitated the workflow.

Keywords: ArcGIS Pro, emergency situations, geospatial data analysis

1. Introduction

Amid an emerging national, or even European security crisis, it is necessary to analyse the response capacity to different emergency situations. Such analyses involve population related datasets and can be carried out through a geographic information system.

A geographic information system is a system that creates, manages, analyses and maps any type of data [11], offering the possibility to view, query, analyse and interpret data, in order to understand relationships, models and trends [4].

In this study we are intending to use spatial analysis within a geographical information system to observe the response to emergency situations in Craiova and to investigate the relationship between the population and different institutions or other critical points of interest such as civil protection shelters.

2. The State of the Art

In Romania, the institution that is in charge with coordinating the response in case of emergency situations is the General Inspectorate for Emergency Situations, which correlates the actions of the involved institutions, being at the same time a national contact point in relation to international governmental and non-governmental organizations with responsibilities in the field [5], [6].

According to the Technical Regulations entered into force on September 30th, 2005, regarding the national integrated system for the notification, warning and alarming of the population, approved by Order no. 886 on September 30th, 2005, and updated, the warning and alarming is carried out through an integrated system that includes subsystems distributed on the national territory, in order to facilitate hierarchical action from central to local level [9]. At the same time, the problem of unitary application of specific plans and procedures is solved, avoiding potential malfunctions.

Taking into consideration the above-mentioned regulations, the alarm subsystems include sirens, defined as an acoustic warning and alarm equipment for outdoors that facilitates the transmission of multilingual voice messages (instantaneous or pre-recorded), with a sound pressure of up to 123 dB per 30 m, in order to ensure the acoustic coverage of the inhabited areas, consistent with the technical alarm projects.

Thus, the existence of technical alarm projects is necessary, a good example being the Audibility Study for the development and completion of the notification-alarm system of the population in civil protection situations within Craiova municipality [10]. The number, type of warning and alarm means, as well as the installation sites chosen in order to guarantee the alarming of the localities and the economic operators shall be established in the audibility studies [8]. According to Law no. 481 of November 8th, 2004 on civil protection – republished, it is stated that civil protection shelters are specially arranged spaces used for protection in specific situations, designed, executed, equipped and authorized according to the norms and technical instructions elaborated by the General Inspectorate for Emergency Situations (IGSU) and approved by the Minister of Administration and Interior (MAI).

Taking into account these aspects, hence the importance of knowing the situation regarding the travel time of ambulances from hospitals to these shelters, the coverage of sirens, etc. resides.

3. Materials and Methods

This study was conducted using the ArcGIS Pro and ArcGIS Online software products. ArcGIS Pro is a desktop GIS application developed by Esri, used for integrating data from multiple sources, advanced analysis, modifying, viewing and sharing data through other GIS applications, such as ArcGIS Online [1].

ArcGIS Online is a cloud-based software used to create and share interactive web maps. The created maps can be shared with specific groups or with everyone, and the data imported into ArcGIS Online can be modified and updated without affecting the maps and applications that are already using this data [2].

ArcGIS Living Atlas of the World is a collection of geographic information across the globe that includes different maps, applications, and data layers [7].

In this study, we used a list of the 4538 civil protection shelters in Romania, published by the General Inspectorate for Emergency Situations [5]. The list contains information about the county, locality, address and latitude and longitude coordinates of each shelter (Figure 1).

Nr. crt.	Județ	Localitate	Adresa adăpostului (nume strada, nr.)	Latitudine	Longitudine
1	AB	Alba Iulia	Bloc ANL – str. Arieșului, nr. 235, bl. E 1	46.084486	23.582668
2	AB	Alba Iulia	Spitalul Județean de Urgență Alba – B-dul. Revoluției, nr. 2	46.071409	23.557064
3	AB	Alba Iulia	S.C. SEWS-R SRL Romania – Str. Alexandru Ioan Cuza, nr. 28b	46.094252	23.600770

Figure 1. Extract From the Table of the Shelters for Civil Protection in Romania [5]

The .xls file containing the data about the shelters was imported into ArcGIS Pro, creating a point layer using the WGS84 coordinate system.

The layer containing data about the population of each administrative-territorial unit from Romania was imported from the ArcGIS Online collection. The data imported for the first analysis can be seen in Figure 2.

Figure 2. Map containing the Data Imported into ArcGIS Pro

The following data on the alarm systems located on the territory of Craiova municipality was extracted from the audibility study for the development and completion of the notification-alarm system of the population in civil protection situations within Craiova municipality, published by the Craiova City Hall: Stereo 70 coordinates: X, Y, and also the alarm range of each system, which is different for buildings up to 20 m tall and buildings over 20 m tall [10].

The point layer that displays the locations of the alarm systems was created in a similar way to the point layer containing the locations of the civil protection shelters. We have also used a layer that included the hospitals in Craiova from the ArcGIS Online collection,. The result can be seen in Figure 3.
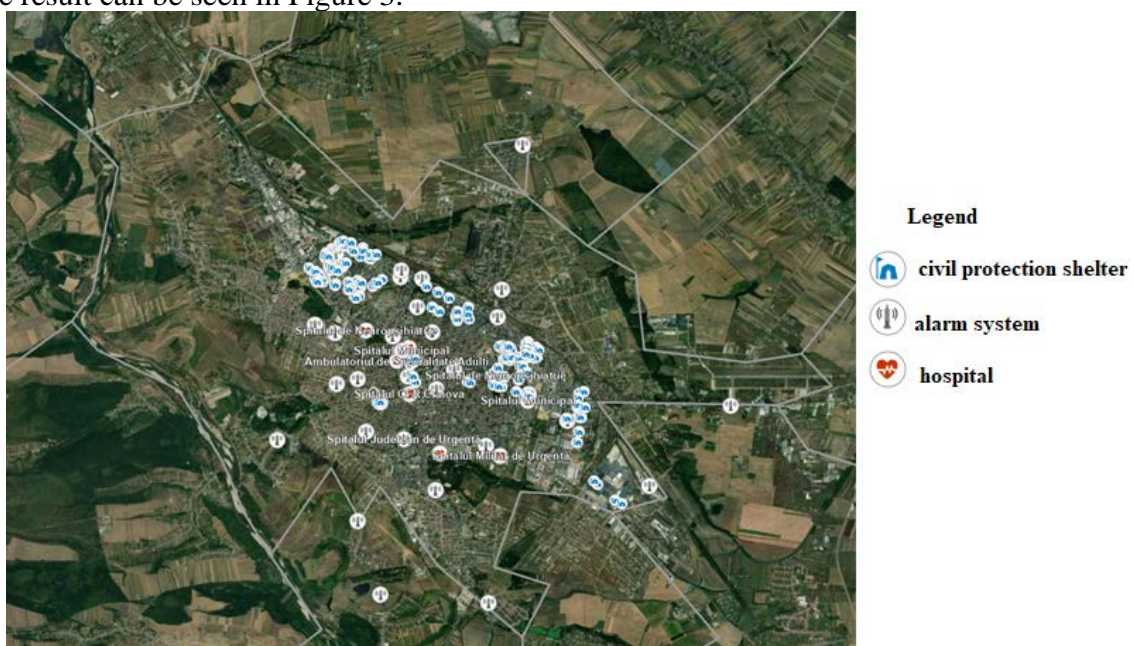

Figure 3. Map of Craiova Municipality Data Imported in ArcGIS Pro

3.1. Geospatial Data Analysis

The first analysis involved calculating the number of civil protection shelters related to the administrative-territorial units, and the result can be seen in Figure 4.
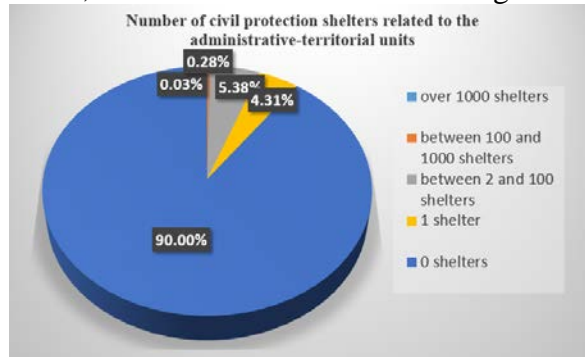

Figure 4. Graphic Display of the Number of Civil Protection Shelters Related to the Administrative-Territorial Units

Such an analysis is relevant if we also refer to the population of each administrative-territorial unit, thus, we have calculated the number of people per shelter for each administrative-territorial unit. Next step was using a Hot Spot Analysis, which requires an input layer, for which the layer containing the number of civil protection shelters related to the administrative-territorial units was chosen, an analysis field, which is the field with the number of people per shelter for each administrative-territorial unit and an output layer, which is the newly created layer. Following this analysis, the geometries of the administrative-territorial units were divided into five chosen classes, each class having a different colour, according to the selected symbology. The results of the analysis can be seen in Figure 5.
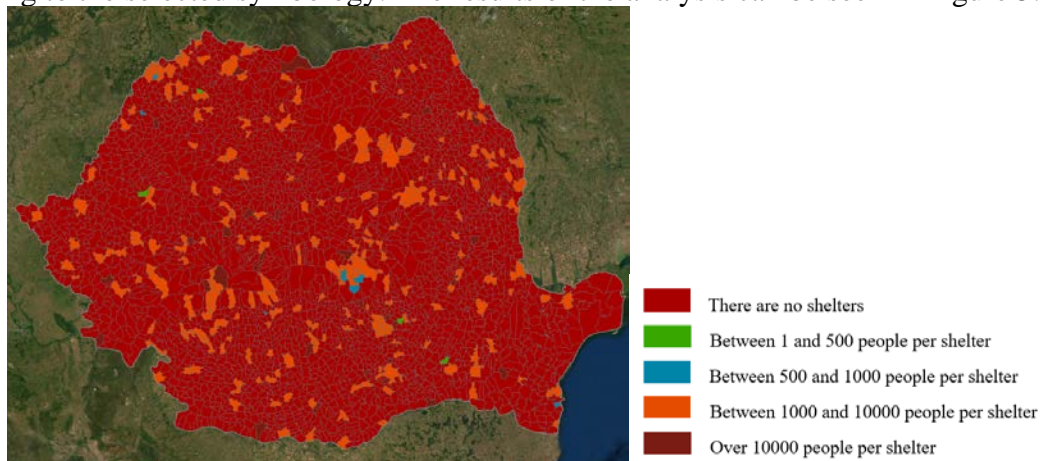

Figure 5. Map with the Number of People per Shelter Related to the Administrative-Territorial Units, Created with the Hot Spot Analysis

The Buffer analysis allows the creation of a buffer zone depending on a specified distance, and can be applied in two ways to obtain two different types of zones [3]:
- Euclidean buffer – measures the distance in a two-dimensional Cartesian space, where the Euclidean distances between two points (straight lines) are calculated on a flat surface;
- Geodesic buffer – takes into account the shape of the Earth (ellipsoid or geoid). The distances between two points are calculated on a curved surface.

We have created two analyses: one for buildings up to 20 m high, and another for buildings over 20 m high. As input data, the layer with the alarm systems was selected, for the

analysis field, the field with the alarm range was selected – separately for buildings up to/over 20 m high, the chosen method was the planar one, to create a Euclidean Buffer, and the output layer was the newly created layer. The results of the analysis can be seen in Figure 6.
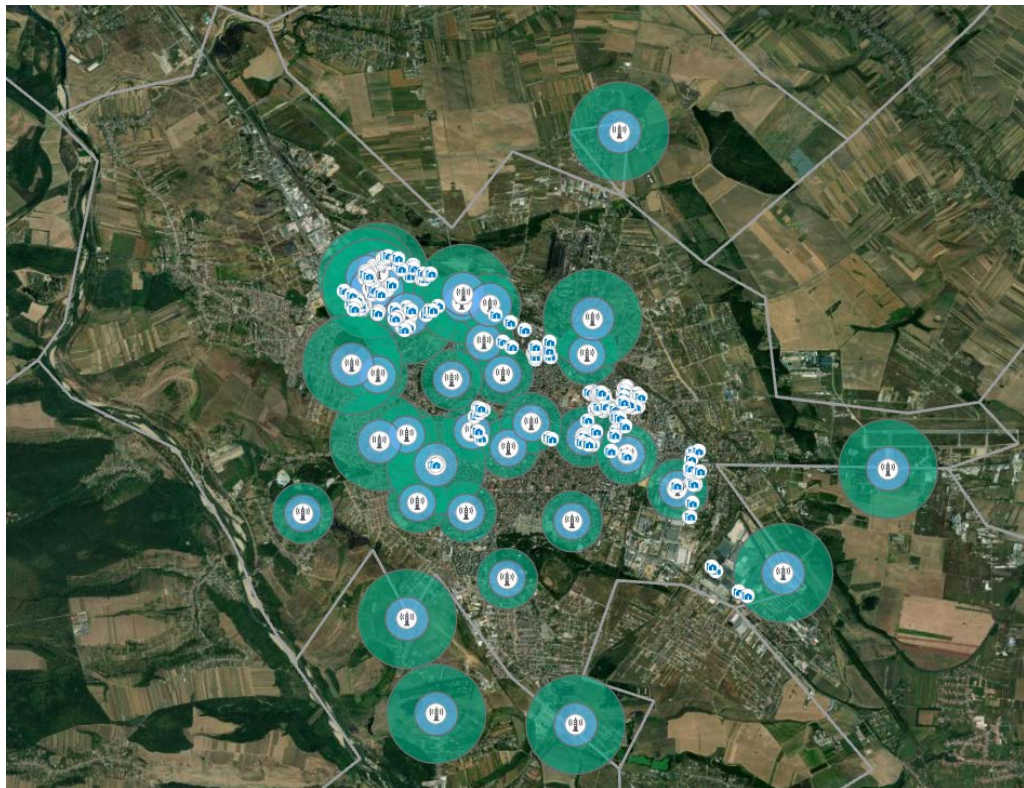
Legend

Alarm range for buildings over 20 m tall

Alarm range for buildings under 20 m tall

Figure 6. Map with the Alarm Ranges of the Alarm Systems, for Buildings over/under 20 m Tall

Another analyse we proposed was to identify the shortest route, calculate the driving time, find the nearest facilities, etc. For the analysis of the driving surfaces, we used the road network from Living Atlas and the first step was to create an analysis layer, with the following layers: Facilities, Polygons, Lines, Point Barriers, Line Barriers and Polygon Barriers.

To identify areas that could be reached by the ambulances from the hospital in 5 minutes or in 10 minutes, we used the layer containing the hospitals and the analysis parameters shown in Figure 7. The results of the analysis can be seen in Figures 8 and 9.
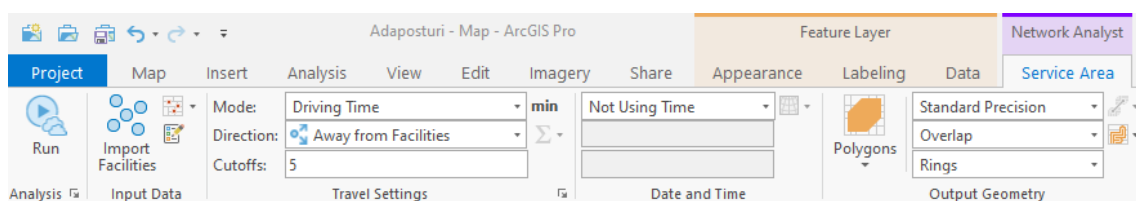

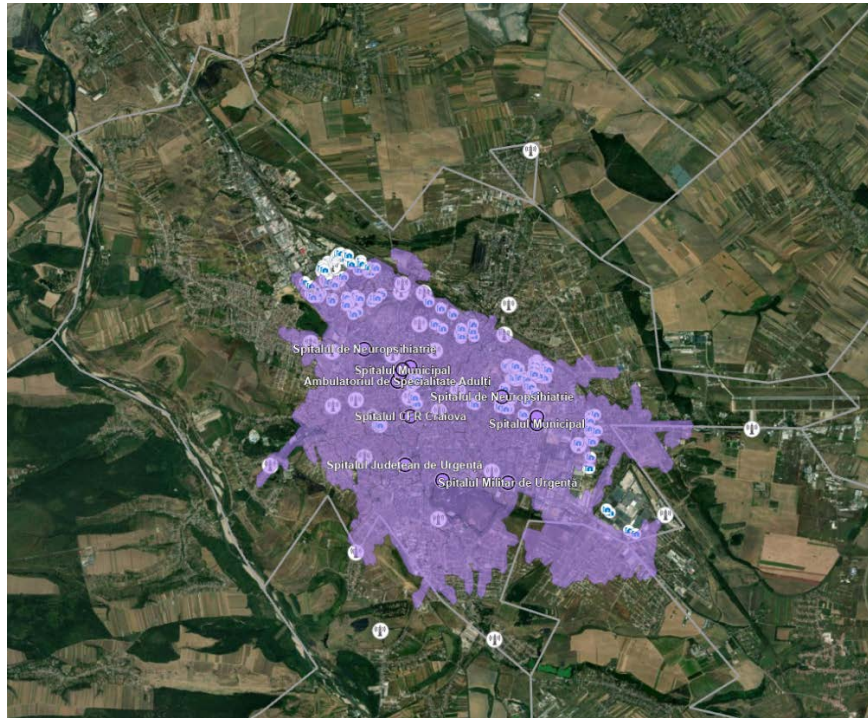Figure 7. Setting the Parameters for the Analysis of the Driving Surfaces

Figure 8. Map of Areas Covered by Ambulances from the Hospital within 5 Minutes
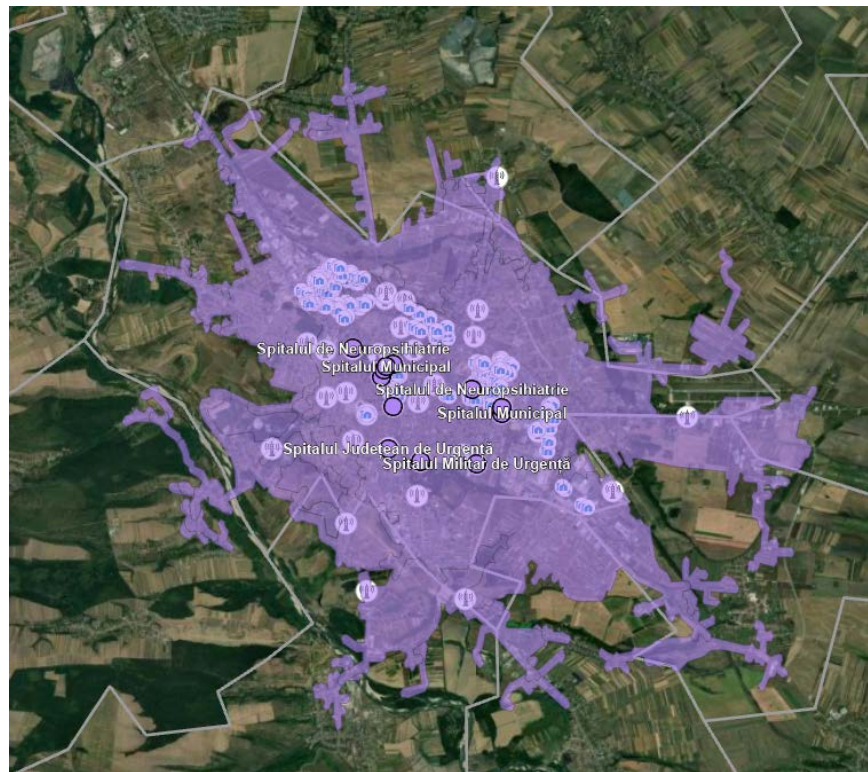

Figure 9. Map of Areas Covered by Ambulances from the Hospital within 10 Minutes

We also intended to calculate the routes from the civil protection shelters to the nearest hospitals, thus, we created an analysis layer which included the following layers: Facilities, Incidents, Routes, Point Barriers, Line Barriers, Polygon Barriers. The Facilities layer was associated with the layer including the hospitals in Craiova, and the Incidents layer was associated with the layer including the civil protection shelters in Craiova. We used the

parameters settings from Figure 10: mode – driving time, to take into account the established driving time of 10 minutes and the direction – towards the facilities. The results of the analysis can be seen in Figures 11 and 12.
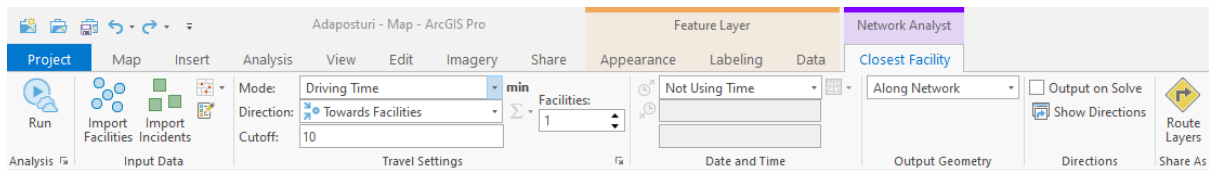

Figure 10. Setting the Parameters for the Closest Facilities Analysis

ObjectID *	Shape *	FacilityID	IncidentID	Total_TravelTim	Total_Kilometers
1	Polyline M	3	1	7.769686	2.951011
2	Polyline M	3	2	7.917416	2.975631
3	Polyline M	3	3	3.817345	1.61517

Figure 11. Extract from the Attribute Table of the Layer with the Routes Resulting from the Closest Facility Analysis

4.   Results and Discussion

Following the first analysis, it was found that 90% of the administrative-territorial units do not have any civil protection shelter, 4.31% have a single shelter, 5.38% have between 2 and 100 shelters, 0.28% have between 100 and 1000 shelters and 0.03%, which means a single administrative-territorial unit – Bucharest, has over 1000 shelters.

Choosing a satellite image as a base map proved to be very useful in this analysis, since it is clear from it that the alarm range in civil protection situations does not offer enough coverage, being insufficient, as there are residential areas where the alarm systems cannot be heard.

In Figure 8, it is noticed that the ambulance cannot reach all the civil shelters in 5 minutes, and in Figure 9, we can see that 10 minutes is enough to reach all the shelters. That is why in analysing the routes between hospitals and shelters we set the driving time to 10 minutes.

Figure 12. Map of the Routes between Civil Protection Shelters and Nearest Hospitals

5. Conclusions

The possibilities for emergency and civil protection response analysis using GIS tools are numerous and can help to identify problems and subsequently improve the infrastructure in these fields.

The advantages of using GIS to analyse the response to emergency and civil protection situations are reducing the time needed to study different situations and phenomena, as well as the easy visualization of the results. These results can also be easily interpreted and understood by the general public, utilizing an interactive map being much more beneficial than extracting the information from documents and tables.

6. References

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7. Acknowledgements